Interview with Professor Chandra Wickramasinghe CMath FIMA

In 2005, the first Asian Power 100 list named Chandra Wickramasinghe as one of the most influential Asians living in the UK. He was born in Sri Lanka in 1939 and was educated at Royal College, Colombo and later at the University of Ceylon. In 1960, he obtained a First Class Honours degree in Mathematics and won a Commonwealth scholarship to proceed to Trinity College Cambridge. He commenced work in Cambridge on his PhD degree under the supervision of the late Sir Fred Hoyle. I remember reading about him in the newspapers all those years ago and this image of the young researcher pondering over the workings of the universe with charismatic thinkers like Fred Hoyle inspired my interest in science.

You were born in Sri Lanka and educated at Royal College, Colombo where you obtained a first class degree in mathematics. What attracted you to the subject?

I think I was an artist at heart right from an early age. I enjoyed looking at beautiful sunsets. I was also a voracious reader of English literature. By the age of twelve I had read a lot of Shakespeare and poetry. We had an excellent library of books at home that I dipped into in my teens. My school, Royal College, Columbo, which was modelled on public schools like Eaton and Harrow, taught extremely well. The mathematics teachers inspired me greatly. The sheer elegance of mathematics attracted me to the subject. As I became enamoured with the universe and with astronomy, I found that mathematics was a necessary tool to explore the world of stars and atoms. My father was a distinguished mathematical scholar at Cambridge University. In the early 1930s he was a B-Star Wrangler which means that he obtained high honours in the mathematical tripos. He was a close associate of Sir Arthur Eddington who encouraged him to stay in research but my father decided to go into the Indian Civil Service. He didn't think there were sufficient opportunities in Ceylon, which was very much in the last stages of the colonial era.

In the middle of June 1955 there was a total eclipse of the sun that had the longest period of totality since 1062. Scientists from all over the world converged on Sri Lanka. One of the experiments I observed was the testing of Einstein's Theory of Relativity that tells you that the light from a distant star would bend as it goes past a massive object like the sun. Eddington made the first such eclipse expedition in 1919. However, the experimental errors were of such a magnitude that it wasn't absolutely compelling. He did it again in 1955 in Sri Lanka and this was a crucial development in science. I felt quite privileged to witness such an important scientific event. At the time, Sri Lanka was a sleepy, colonial country and by no means in the forefront of scientific endeavour. Astronomy attracted me particularly because the environs of the City of Columbo were absolutely pristine and unpolluted. Night after night, one could see the splendour of the Milky Way stretching across the heavens. The romance of the universe attracted me. I put my thoughts about the universe into poetry.

Was it your family connection that led you to choose Trinity College, Cambridge for your PhD degree?

Yes, I chose Trinity because it was my father's old college. Because of my degree examinations in Sri Lanka, I was in the first batch of Commonwealth Scholarships offered to the colonies and the Commonwealth by the United Kingdom. I applied to the Faculty of Mathematics in the early summer of 1960, mentioning an interest in astronomy. Fred Hoyle wrote back offering to be my supervisor. That gave me a great thrill. I had read books like Fred Hoyle's *Nature of the Universe* but I had not realised that he was an external examiner for my degree in Sri Lanka.

What happened when you arrived in England?

I arrived in Cambridge at the beginning of October while Fred Hoyle was in California working with collaborators. A very famous stellar astronomer called Professor Ray A Littleton FRS wrote, asking to see me. I approached that first meeting with a Cambridge academic with some trepidation because I didn't know what to expect. His attitude to research was very strange. He told me that research problems are very difficult because if they were easy, we would have solved them already. Fred returned around Christmas. He was much gentler with new students. Initially, we worked on the reversal of the sun's magnetic field. We came up with a model and published a couple of papers. Later, I told Fred Hoyle that this was becoming boring and asked him if I could do something more exciting in astronomy. He said 'cosmology is up for grabs now. There is a huge cosmological controversy going on as to whether the universe is in a steady state or started with a big bang. Another possible area is to try to understand how stars are formed from the dark material between the stars.' I decided to look at the formation of stars from dust clouds.

In the early Forties, a couple of Dutch astronomers proposed that interstellar dust is made of tiny, microscopic crystals of ice similar to those in the cumulus clouds in the upper atmosphere. Their theory conflicted with the data. By the end of 1961, I had theorised that the dust was a form of carbon rather than little evanescent ice particles. At the beginning, we thought that the dust was like particles of soot that come from a flame, inorganic graphite. As the years rolled on more observations of absorption and scattering became available. The carbon that seemed to fit the observations much better was in the form of organic polymers. The carbon theory was such an important paradigm shift in astronomy that before I had finished my PhD, Jesus College, Cambridge awarded me a prize Fellowship.

You arrived at Cambridge at the time when the controversy over the Steady State Theory and the Big Bang Theory was moving towards a peak. In terms of the popular view, the matter is more or less

settled in favour of the Big Bang Theory. I know that this is not proved 100% to everybody's satisfaction. How do view contemporary cosmology?

They were very exciting times for me. I didn't work on any cosmological problems at the outset but I was witness to everything that was happening. The Steady State Theory of Hoyle, Bondi and Gold had come to a crisis point because radio astronomers led by Martin Ryle claimed in the mid 1960s that they were finding conflicting evidence from radio astronomy. That evidence has subsequently turned out to be equivocal. Another observation made in Bell Labs in the United States by Penzias and Wilson revealed the cosmic background radiation, thought to be a relic of the Big Bang, a prediction going back to George Gamow. This gave the Big Bang Theory *a priori* credibility but, even so, it is not set in caste iron. Throughout the history of cosmology, people have thought that they had the final solution to the origin of the universe and every time they have proved to be wrong. We might have evidence for some huge explosive event that made the bulk of the galaxies that we see around us but that may not have been the unique, singular beginning of the entire universe. There are alternative cosmologies still around that are not as popular as the standard Big Bang Theory. For example, there is the Quasi-Steady State Theory that Sir Fred Hoyle was working on before his death in 2001 together with Geoffrey Burbage and Jayant Narlikar. I think the last word has not been said.

From what you have said about your early work, it seems a natural step to move into the field of astrobiology, which was presumably non-existent at the time. How did this come about?

I didn't set out to do anything connected with biology. My starting point was modelling interstellar dust, how dust scatters and absorbs light. It came about really quite by chance because of the type of interstellar dust and comet dust that we were discovering through our calculations. By 1975, the dust had unquestionably to be mostly organic. Then the organics became more complex. We first had polymers like formaldehyde molecules, poly-formaldehyde and then our models involved polysaccharides – chains of sugar molecules. In the mid Seventies, we published our findings in the high impact journals like Nature and in astronomical journals.

So you started from theoretical predictions of organic materials and presumably went on to seek experimental evidence.

Yes, we moved on to experimental astronomical measurements that were coming to be very close to our predictions. Our model gained plausibility and credibility up to the late Seventies and was widely applauded. Then, suddenly it dawned on us that the production of such organics in vast quantities posed a problem. You can think of making carbon dust easily from smoking, carbon rich stars but how do you make complex biochemicals in the astronomical quantities required? Every three carbon atoms had to be involved in a structure that was essentially indistinguishable from a bacterium. In 1979 we asked, is it biology that is doing this? We assume that life produces 99% of the organics on the earth. We posed the question: why not the same for the cosmos at large?

We explored the current knowledge about how life originated on the earth and there were striking gaps in our understanding. The standard view is that there was a dilute primordial soup of simple organic molecules in the oceans that after a long time became a living system. There is no scientific proof of that. It's just wishful thinking and conjecture. Adherents point to the famous Urey-Miller Experiment where they mixed a bunch of inorganic molecules – water, methane, ammonia – and put electric sparks across them and found traces of sugars and substances of that kind. This is very far from life, which implies a highly ordered informational system. To have the most intricate transformation of non-life to life happening on a tiny speck of dust on a planet like the earth was to us, implausible. We considered it pre-Copernican thinking. No logic demanded that life originate on earth. If you have a highly probable chemical transformation that is involved in life, it will pay to go to the biggest available system which is the universe as a whole, or certainly the galaxy at least. We regarded the evidence from astronomy as being very powerful support. Life didn't start here in a primordial soup but came essentially ready made in fully evolved genetic structures from the universe at large.

We wrote dozens of scientific papers and books that developed these ideas. The books sold well but the scientific community regarded it as heresy to consider any connection of life on earth with the external universe. Twenty years later, these ideas are now almost mainstream. There are searches for life on Mars. Europa is one of the satellites of Jupiter that could be harbouring life. The possibility that comets might also carry the complex building blocks of life is being taken very seriously. The recent Stardust mission brought back cometary material that revealed extremely complex organic structures, although the way they collected dust from the comet Wild-2 precluded the survival of any microbes if they did exist. However, they now have all the tell-tale signs of the building blocks of life in the laboratory. Astrobiology and the connection of life with the external universe is more widely accepted and is certainly fashionable compared with the heresy it once was when we started writing about these things.

Do you feel that the historical conflict between religion and science has shaped the boundaries of the current scientific paradigm?

I think that is certainly true – not necessarily religious constraints alone but even philosophical constraints come very deeply rooted in scientific cultures. For example, if you go back to the Fifth Century BC in classical Greece, they had a very open view on the universe and on life. In fact, the ideas of astrobiology like *panspernia* that we now consider to be modern were very much part and parcel of Greek thinking. *Panspernia* derives from Greek roots – *pans* everywhere and *spermata* seeds – means 'seeds everywhere'. The Greeks understood that the earth was not the centre of the solar system. It was also well understood, and this was where I have been influenced personally, in Buddhist and Vedic traditions in ancient India. The Vedic and Buddhist perceptions of the universe seems to embody some kind of intuitive knowledge that unravel to some people in states of deep meditation. I don't understand what meditation means but it is really delving into one's own conscience. It seems that by doing so, these aesthetics were able to prize out certain very modern – almost bewildering - facts about the universe that are well documented in the literature and traditions of India.

NASA's Stardust mission extracted material from a comet; the Spitzer space telescope seeks infrared signatures of complex molecules. Has observation and experimentation vindicated the theories of astrobiology?

The ultimate goal of astrobiology as I see it is to explore the universality of life, to discover that there is life in comets, there is life on planets, and that they are all connected. I see life on earth as part of a connected chain of being that extends out from the solar system to the remotest corners of the cosmos. That is not everybody's vision because there is a group of individuals, quite powerful individuals now, who assert that life is very easy to get started. They propose that wherever physical conditions become congenial, life springs out of almost nothing. Now I find that to be counter-intuitive and totally lacking in experimental evidence. Unfortunately, NASA conceived the Stardust mission in 1999 when they did not consider it even remotely plausible to find life in comets. They collected the dust in a way that was essentially destructive to any life. All that remained were the broken up fragments of living material, which is interesting and shows that these could be degraded bacteria.

There was another NASA space mission in 2005 on July 4th called Deep Impact. They rammed a washing-machine-sized probe on to the surface of a comet called Temple 1 at a huge speed of 25,000 miles a second and observed the material that came out of it to determine what it was made of. The Temple 1 observations revealed huge amounts of complex organics and totally confounded the standard 'dirty ice' model. The comet was organic. There was evidence of liquid water as our theoretical predications had indicated some 20 years earlier. There was also evidence of the kind of clay that you get on the earth. All the ingredients for life were present in the comet as far as one could ascertain from infrared spectroscopy. Future missions now in the planning stage will be much more deliberate in trying to either prove or disprove the existence of intact life in comets.

I was fortunate to link up with the Indian space research organisation in 2001. We flew balloons to heights above 40 kilometres to collect large quantities of stratospheric air and aerosols and looked for evidence of micro-organisms. The logic was to pick up comet dust before it became embroiled in the biosphere of the earth. At 41 kilometres there is not a chance that any living material from the earth would get up as high as that. We looked very carefully here in Cardiff, in Sheffield and various other places in the United States and found what we believe to be compelling evidence of micro-organisms in the stratosphere. Now that hasn't carried absolute conviction amongst all our peers. It has been published in peer reviewed journals and so on, but the major question mark is, are we sure that this is not contaminants? We have arguments that say that they are not contaminants because they are very different organisms. I think more of that kind of experimentation is needed at very modest costs. The US Stardust mission and the comet missions cost billions of dollars whereas the ISRO experiments cost a fraction of a million dollars.

For me, the idea that life originated on earth as an exception or accident has always presented all sorts of philosophical and scientific problems. If you take the view that life forms from materials as a natural process unfolding from the development of stars then that particular problem ceases to exist. You have written about panspermia and life as a universal phenomenon, how close do you feel we are to understanding the origins of life and the universe?

All that we have done, both in theory and in experimentation, is to show that life on the earth probably derives from a bigger system and easily transports from one cosmic setting to another. That view was contentious, even heretical at the time we first talked about it. Now I think people are coming round to accepting that life is adaptable and highly resistant to complete destruction. Once formed, microbial life has enormous powers of survival far in excess of what it would need if life easily originated everywhere. Microbes have the capacity to be space travellers, to survive the harshest of environmental conditions. How the cosmic setting first gave rise to life is still a multi-billion dollar question that remains unanswered.

Laboratories around the world have been conducting experiments to try to see how such a transition from non-living organic molecules to life might occur. One theory is that there was an initial RNA world meaning that the present life system depends on a combination of RNA, genetic material in the form of DNA and proteins that have to go hand in hand. The DNA protein system is seen as far too complex to be a first step in the origin of life. There have been many suggestions that earlier steps had been in place before the final form of life came into being. I see no evidence for this. The simplest living system, which is a microbial, has a super-astronomical information content. To arrive at that in a small soup and in a small cosmic setting is difficult to comprehend.

It becomes easier as you go to bigger settings. But even in a big setting you need to overcome the improbability – that is a question that still has not been convincingly answered by anybody. I don't have an answer to that. I think if one discovers an ultimate origin of life it may be fair to say that one has discovered 'God'. It's perhaps the hardest problem of science to solve. There are various ideas that I have been running through my mind and also running through other peoples' minds that somehow the properties of life have been hardwired into the structure of matter itself. Perhaps, deep in the wave functions of the carbon atom and in the other atoms that are involved in the formation of life, the tendency to arrive at life is written in a subtle and as yet undiscovered way. Having said that, that doesn't answer any question and it is not strictly a scientific statement but it is wishful thinking that the scientific method might eventually lead to our unravelling the biggest problem of all which is the origins of life. One of the criticisms that people level against panspermia is that it doesn't explain anything, it just pushes the origin of life to somewhere else. I think that is unfair and it's not something that I would take as a valid criticism because scientifically we really need to know where life came from, whether it came on the earth in a little warm pond or whether it came from a bigger system. All the evidence from biology, from astronomy and from geology is pointing in the direction of a space origin of life. Life appears on the earth at the very first moment that it can survive.

It was once thought that there was a comfortable billion year period between the development of the oceans, the formation of a congenial environment on the earth and the arrival of the first living cells. That interval has more or less been squeezed out of the geological record; it's a hundred thousand years or even less. It appears almost in a flash at the very first moment that life can survive. It appears on the earth, pointing in my view almost inexorably to the cosmic connection.

I understand you played a key role in the setting up of the Institute of Fundamental Studies in Sri Lanka. What was the intention behind this organisation?

Having grown up in colonial Sri Lanka, I felt after coming to Britain and making some reputation in science, a responsibility to give something back to my original homeland. That may seem a bit arrogant but within me I feel that I would like to be part of their scene as well. So in the early 1980s I had the good fortune of being invited by the then president of Sri Lanka, J.R. Jayewardene, who was very influential, to be one of his science advisors. He had just completed a state visit of India and had seen for himself what a marvellous job they were doing in science. He said 'you are a well known Sri Lankan scientist abroad, why can't we have a similar things happening in Sri Lanka?' Academia in Sri Lanka was mostly concerned with teaching. It wasn't research-centred at all. I took it on myself to try to help them to set up the Institute of Fundamental Studies. I spent about a year and a half directing it and commuting between Cardiff and Sri Lanka. It was partially successful but not entirely, because we lacked scientists.

I have also had links with the United Nations in various ways to promote science in developing countries because I think every nation, no matter how impoverished or under developed it is at the present time, deserves to take part in the most exciting enterprise that we are involved in as a species at the moment, which is science. Some of these countries, especially those in the Indian subcontinent, were the birthplace of mathematics and astronomy so we should give them another chance to take part in their re-development by rediscovering science. I was also invited by the Vice Chancellor of the University of the West Indies in Jamaica to try to do the same thing for them some years later. It is not the easiest thing to do but I feel that it has got to be done some time, sooner rather than later. Having these links with the Third World was also very important for me – particularly with India. Hence my collaboration with the Indian Space Research Organisation (ISRO), which is as good a space research organisation as any. They have successful launches of satellites whereas some of the European efforts have failed.

In a sense, you have an almost global perspective on your principal fields of mathematics and astronomy. What do you see when you look beyond the conventional western view?

I have no doubt that mathematics and astronomy are very much part of the history of our civilisation. I have talked to the Master of my college, Jesus College who was an archaeologist. We often discussed the degrees of sophistication of archaeological sites and ancient civilisations. The best index of the level of advancement of an ancient civilisation is in its mathematics and its astronomy. The emergence of triangulation came in response to the computational need to measure the distances to stars. We can even regard the development of calculus as a response to an astronomical need for understanding planetary motions. One of the things I have been really interested in throughout my career was the study of the historical aspects of science and to see where these various ideas in geometry and mathematics came from in the distant past. Modern historians of mathematics and of science tend to be Eurocentric. They don't really look beyond classical Greece. Most of the major discoveries in mathematics and astronomy came from India. What I didn't realise until recently was that a guy called Aryabhata the Elder who lived from around 500 AD was unquestionably the pioneer of elliptical orbits. He sorted out the motions of planets and elliptical orbits about 1000 years before Copernicus and Newton. Translations are available in the Indian Academy of Sciences.

What differences do you see in education between Britain and Asian countries?

I think that there is also a lesson to be learned here. When I visit schools and universities in these countries, I see a totally different attitude from that prevailing in the UK. Kids are there to learn. You feel it when you go into a classroom. I don't see that happening in Britain very much now. The culture here is now mostly one of spoon-feeding. Students just want to get their degrees and get away to make money. The quality of education is much better than in some places here. In the East, they regard numeracy as a huge asset. Computers have proved beneficial in the Western World in various ways but they also decrease levels of numeracy. Kids here cannot multiply or divide or do anything without the pocket calculator. We should do something about levels of numeracy and scientific engagement.

A great thing about maths in terms of training people to think in a much broader context is appreciation of the nature of proof. That seems to be completely lost. I don't know what happened to it. We have first class honours graduates from universities here who haven't the foggiest idea of what constitutes mathematical proof. There is a greater dependence on algorithms than on proof. They want to know the formula and that's it. They don't bother to find out why it turns out to be that way. I think that is to the detriment of our mathematical culture and our long term mathematical progress. We cannot have a generation of mathematicians who do not understand the nature of proof.

Do you think that has any connection with the move towards teaching becoming more vocationally-based?

There is a big problem here. I think we have moved completely away from the academic interests in university courses to a vocational interest. The payoff we have for that is the lack of appreciation of the basic structure of the subjects we are supposed to be exploring in our classroom. I think something has to happen otherwise the differences in educational standards in the East and the West are going to be glaringly obvious in the generation to come. China and India are burgeoning as economic and industrial giants with much better trained scientists and mathematicians. My wife has been helping to regenerate schools after the tsunami in Sri Lanka. I have been going along with her and seeing how the kids are taught their tables by rote learning and they seem to enjoy reciting them. I can't see any of the kids here doing that.

I believe we should return to traditional methods of teaching and communicate the pleasure of mathematics through perhaps games and puzzles and so on. This has to be restored otherwise kids are just going to lose interest in maths. I think we should teach the importance of mathematics in the real world, which is something the IMA does beautifully. Mathematics is fun but it's not only fun – it's absolutely important for our survival.

In the public mind, your career is very much associated with that of Sir Fred Hoyle. How do you view that association now?

At first, I found it intimidating because he was such an icon of science. I think he was unquestionably the astronomical giant of the 20th Century. So it was quite daunting for me to start working with him. I developed a relationship with him mostly through my poetry and writing. He had a beautiful style of writing. When we wrote our books together there was hardly a difference between my style and his. Eventually the styles merged. His perceptions of the world were really quite amazing. If you were to tell him something that concerned the world around him, he would find connections with all manner of things. I found his convergence of thought exhilarating. Bondi worked with him for about five years, Narlikar for about 15 but I worked with him solidly throughout 30 years so I was his longest running collaborator.

The first half of the collaborations won us the greatest acclaim in terms of awards but then we came into the life from space theory. In fact, Fred warned me that if we go in this direction we are going to be ostracised by our community, by our peers. 'Are you prepared to do that?' I replied that what I really want to do is find out the truth. I don't give two hoots whether I am acclaimed by any scientific body or not. So that's the route that we took and we were really kindred spirits in exploring the universe in a maverick style, flouting authorities. But in the long term it paid off. Fred often told me that history would vindicate us, maybe not in his lifetime. That statement seems to be amazingly prescient because even now, following his death, the aspects of our theory that were controversial in 2001 are now mainstream. People don't remember that the first papers that suggested these were published by us in Nature in the 1970s. They were theories that were far ahead of their time when we worked on them but now they are coming into fruition. So that is quite pleasing.

There is a way of bringing in new ideas that hides the controversial element by leaving out certain words or phrases in your terminology.

Exactly, and if you are an arch political animal which neither of us were, we would have got a great deal of mileage in that way but we decided essentially to be really blunt about things and to say things as we felt. It was a rough ride. At the end of my book I say 'my journey with Fred Hoyle over nearly four decades as it turns out was always filled with action adventures into uncharted sometimes dangerous terrain and the excitement of new discoveries. If I were given another chance I would gladly follow the same path.'❑

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REFERENCE

'A Journey with Fred Hoyle: The search for cosmic life' by Chandra Wickramasinghe, World Scientific, 2005, ISBN 981-238-912-1